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Invited Paper

Supercontinuum comb sources for broadband communications based on AlGaAs-on-insulator

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ABSTRACT

We experimentally demonstrated 10 GHz frequency comb spectral broadening in an AlGaAsOI nano-waveguide with the peak power of only several watts. The spectral broadened 10 GHz frequency comb has high optical signal to noise ratio (OSNR) at the output of the nano-waveguide. As far as we know, it is the first photonic chip based frequency comb, relying on spectral broadening of a 10 GHz mode-locked laser comb in an AlGaAsOI nano-waveguide, with a sufficient comb output power to support several hundred Tbit/s optical data.

Keywords: Supercontinuum generation, fiber optics communications, nonlinear optics, integrated optics, waveguide

1. INTRODUCTION

As cost and energy consumption are becoming limiting factors in high-capacity systems, using fewer lasers with less energy consumption grows desirable and demonstrations of ultra-high-capacity optical transmission based on nonlinear fiber based spectral broadening of a seed laser frequency comb have been reported[1, 2, 3, 4]. The prospect of moving the fiber-based frequency comb sources onto a photonic chip platform holds many attractive features, including ultra-high bandwidth, stable polarization and phase, absence of stimulated Brillouin scattering (SBS), and the possibility of photonic integration with a seed laser [5].

AlGaAs-on-insulator (AlGaAsOI) has shown to be an ultra-efficient nonlinear material platform[6, 7, 8]. It combines high intrinsic material nonlinearity (on the order of 10^{-17} W/m^2), large index contrast between AlGaAs (3.3) and silica cladding (1.5), and low linear and nonlinear losses. The bandgap of AlGaAs can also be engineered by changing the Al concentration to avoid two-photon absorption (TPA) in the telecom wavelengths.

In this paper, we present the photonic chip based frequency comb, relying on spectral broadening of a mode-locked laser comb in an AlGaAsOI nano-waveguide, with a sufficient comb output power to support several hundred Tbit/s optical data [9]. We use a 33.6 nm wide part of the generated comb spectrum to carry 80×40 Gbaud WDM channels with PDM-16-QAM modulation format. The high comb OSNR allows us to send the signal over 30 spatial channels, and we demonstrate successful 9.6 km transmission in a heterogeneous 30-core fiber reaching a total of 661 Tbit/s after FEC overhead subtraction.

2. SPECTRAL BROADENING OF A 10 GHZ MODE-LOCKED LASER COMB

Figure 1 shows the experimental setup for frequency comb spectral broadening in an AlGaAsOI nano-waveguide. An erbium glass oscillator (ERGO) generates a 10 GHz pulse train at 1550 nm with picosecond pulse width. The 10 GHz modulation frequency is locked to a microwave oscillator with an accuracy of ~Hz and the absolute frequency of the pulse can be fine-tuned without the need of external reference laser. After amplification in an erbium-doped fiber amplifier (EDFA), the pulses are launched into the AlGaAsOI nano-waveguide. A polarization controller is used to align the pulses to the transverse electric (TE) mode of the waveguide and an optical spectrum analyzer is used to record the output spectrum.

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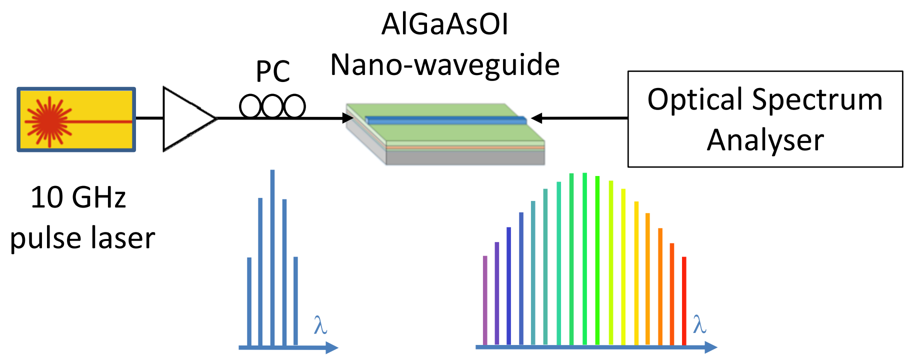
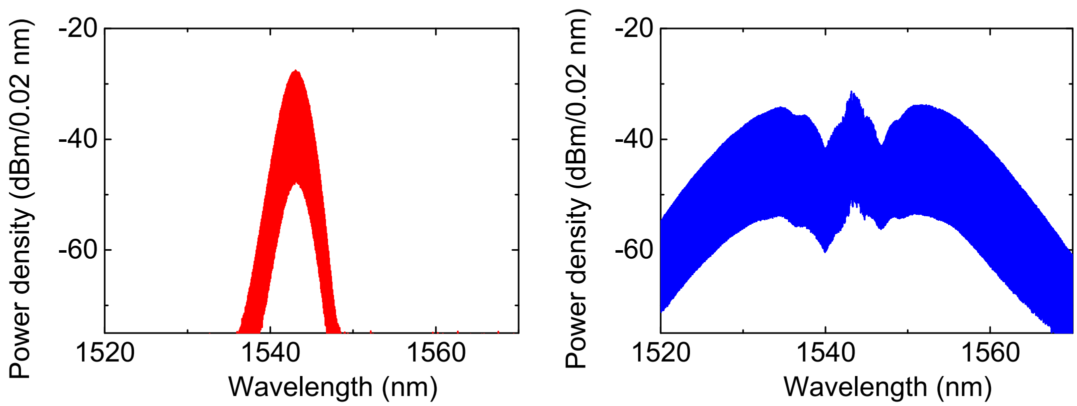


Figure 1. Experimental setup for frequency comb spectral broadening using an AlGaAsOI nano-waveguide.



(a) (b)

Figure 2. Optical spectra of 10 GH mode-locked laser frequency comb (a) and spectrally broadened frequency comb at the output of the AlGaAsOI nano-waveguide (b).

Figure 2 (a) shows the spectrum of the ps pump pulse at the input of AlGaAsOI nano-waveguide (Fig. 3(a)) and Figure 2 (b) shows the spectrum at the output of the waveguide with an average launched power of 19.3 dBm (peak power of ~5.6 W). The broadened spectrum at the output of the AlGaAsOI nano-waveguide has a 20-dB bandwidth of ~44 nm, which is used as the wavelength division multiplexed (WDM) light source.

3. SINGLE SOURCE OPTICAL TRANSMISSION USING THE SPECTRALLY BROADENED FREQUENCY COMB

Figure 3 (c) shows the experimental setup of single source optical data transmission using the spectrally broadened frequency comb. The single source laser in the transmitter is an Erbium glass oscillating mode-locked laser, which produces 10-GHz pulses (1542 nm, 1.5-ps FWHM). The pulses are amplified and used to generate an optical frequency comb based on self-phase modulation (SPM) in the AlGaAsOI photonic chip (Fig. 3 (b)).

The estimated OSNR is ~ 43 dB at 1552 nm and ~ 30 dB at 1563 nm. The broadened spectrum is equalized in a wavelength selective switch (WSS) and the inhomogeneous part in the center is replaced by the original spectrum from the mode-locked laser through another path, which results in a flat and stable frequency comb [1]. The equalized frequency comb works as the light sources for 80 WDM channels with 50 GHz spacing. For each WDM channel, the signal is modulated with PDM-16-QAM and then OTDM multiplexed to 40 Gbaud. The signal is transmitted through the 9.6-km 30-core single-mode fiber, with a total data capacity of 661 Tbit/s [9].

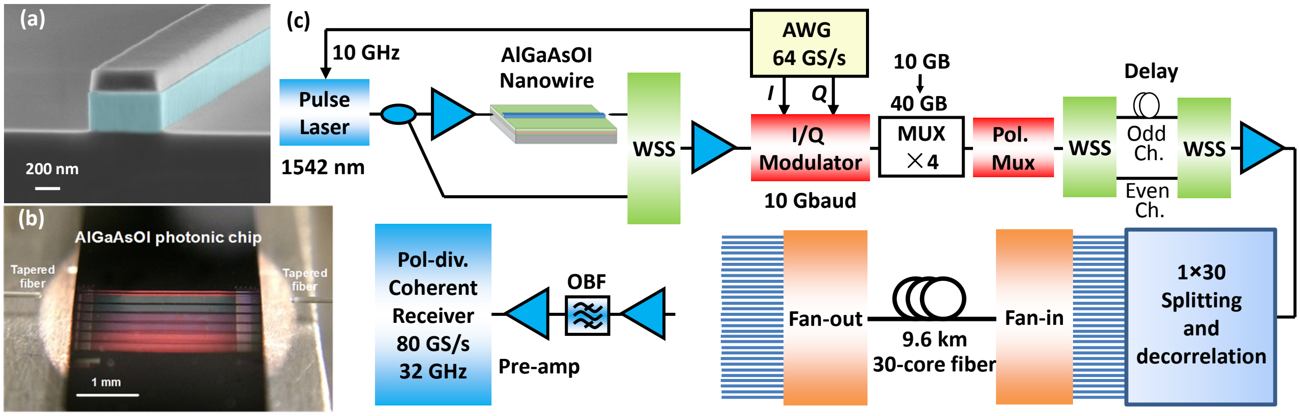


Figure 3. (a) SEM picture of a fabricated AlGaAsOI nano-waveguide (denoted by the artificial blue color). (b) Photograph of the AlGaAsOI photonic chip. (c) Schematic of the experimental setup for the 661 Tbit/s single-source AlGaAs frequency comb transmitter for 30-core transmission demonstration.

4. CONCLUSION

We have demonstrated 10 GHz spectrally broadened frequency comb based on an AlGaAsOI nano-waveguide, which has a 20-dB bandwidth of ~44 nm and cover the telecom C band. The spectrally broadened 10 GHz frequency comb has enough OSNR to carry 661 Tbit/s data in a fully loaded 30-core fiber. This is the highest reported amount of data carried on the light generated from a chip-based single-source transmitter, and we demonstrate successful 9.6 km transmission.

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